Graphing Skills
Reading, Constructing and Analyzing Graphs

Line Graphs

There are all kinds of charts and graphs used in the science classroom. Graphs are useful tools in science because trends in data are easy to visualize when represented graphically. A line graph is beneficial in the classroom for many different types of data, and is probably the most widely used scientific graph. Line graphs can be used to show how something changes over time or the relationship between two quantities. They can also be readily used to *interpolate* (predict between measured points on the graph) and *extrapolate* (predict beyond the measured points along the same slope) data points that were not actually measured. Analysis of these graphs provides very valuable information.

PURPOSE
In this activity you will learn the basic procedure for constructing and analyzing line graphs.

MATERIALS

3 sheets of graph paper	data
pencil	ruler

PROCEDURE

1. Follow along with your teacher as a sample line graph is constructed. Label a blank piece of graph paper as your teacher explains the important components of a line graph.

2. When instructed, use the sample sets of data to construct line graphs. Place only one graph on each sheet of graph paper and use as much of the graph as possible to display your points. ***Do not connect the dots!*** Draw the best smooth curve or line of best-fit as your teacher demonstrated.

3. Following the steps below will help ensure that all components of the graph are correctly displayed.
   a. **Identify the variables**. Independent on the x-axis and dependent on the y-axis
   b. **Determine the range**. For each axis subtract the lowest value data point from the highest value data point.
   c. **Select the scale units**. Divide each axis uniformly into appropriate units using the maximum amount of space available. (Remember that the axes may be divided differently but each square along the same axis must represent the same interval.)
   d. **Number and label each axis**. Be sure to include units where appropriate as part of the axis label.
   e. **Plot the data points as ordered pairs**. (x,y)
   f. **Draw the best straight line or best smooth curve**. For a straight line, use a straight edge to draw your line in such a way that equal numbers of points lie above and below the line.
   g. **Title the graph**. The title should clearly describe the information contained in the graph. It is common to mention the dependent variable (y-axis) first followed by the independent variable (x-axis).

4. After creating graphs for the 3 data sets below, use the graphs to answer the conclusion questions on your student answer page.

Sample Data Set 1: The following set of data was collected while experimenting with position and time of a miniature motorized car traveling on a straight track.

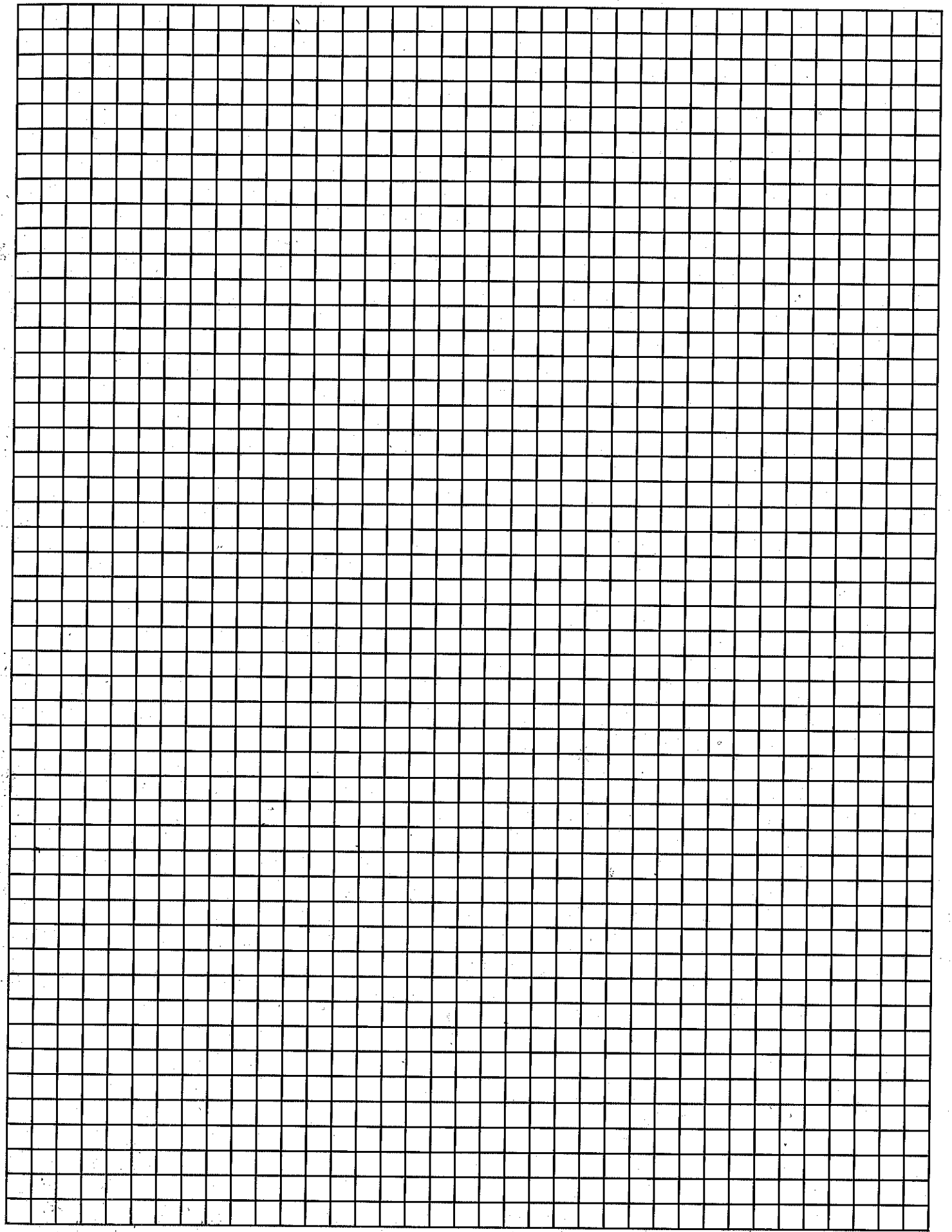
Time (minutes)	Position (meters)
0	0
5	15
10	30
15	45
20	60
25	75

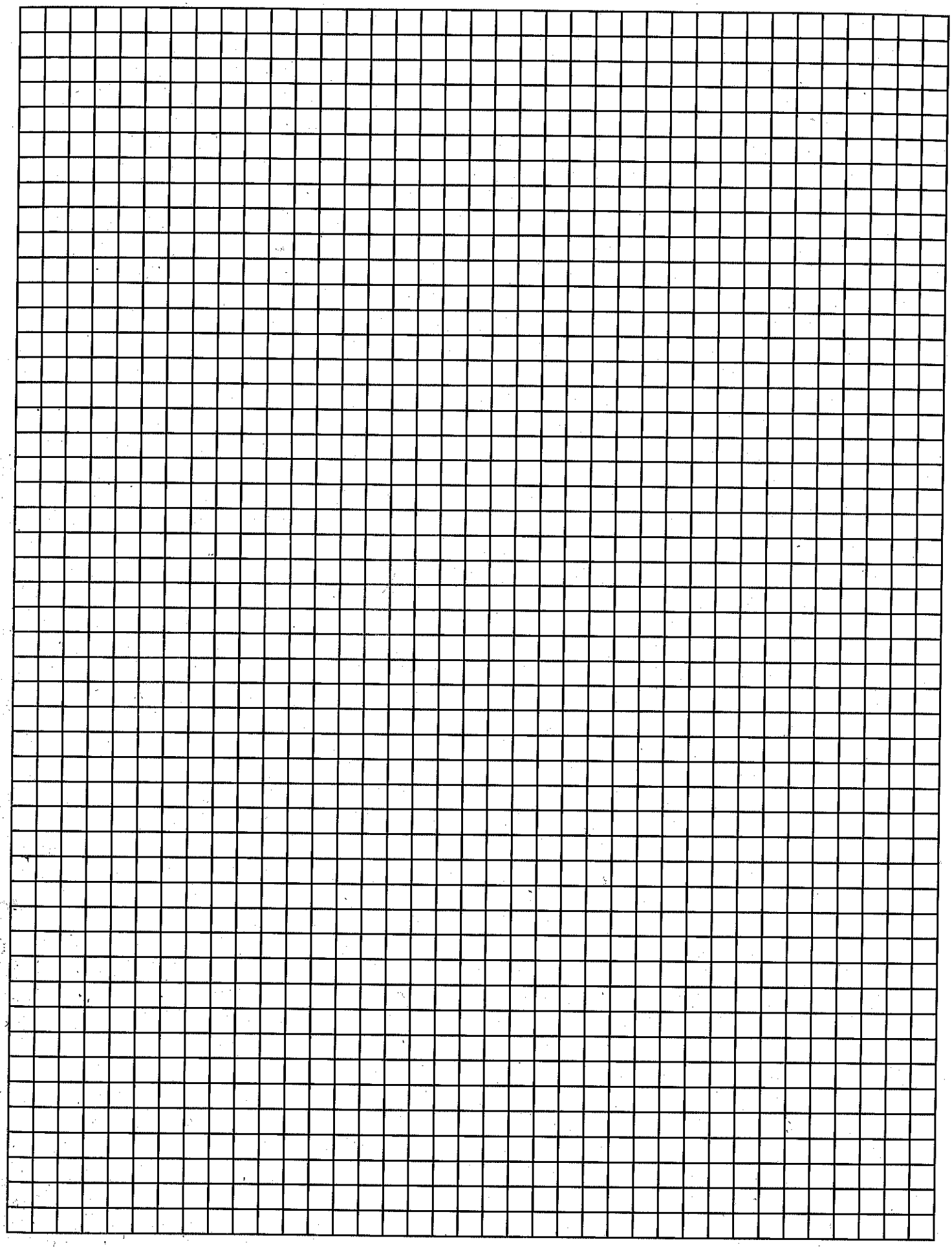
Sample Data Set 2: The following set of data was collected during an experiment to find the density for an unknown metal.

Volume (cm^3)	Mass (g)
0.18	2.00
0.44	5.00
0.66	7.50
1.41	16.00
2.11	24.00

Sample Data Set 3: The following set of data was collected during an experiment studying the effect of light on the process of photosynthesis.

Time (minutes)	Percent Transmittance (%)
0	32.5
5	54.3
10	63.5
15	65.0





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DATA AND OBSERVATIONS

Staple your completed graphs behind this answer page.

CONCLUSION QUESTIONS

Using the graphs that you constructed, answer the following questions:

Sample Data Set 1:

1. What is the independent variable for this graph? Explain.

2. Determine the position of the car after 2.5 minutes.

3. If the experiment were carried out for 30 minutes, what would be the position of the car?

4. Calculate the slope of the line drawn. What does the slope of this line represent? Explain.

5. Write the equation for the line and substitute the value determined for the slope.

Sample Data Set 2:

1. What values were considered when creating the scale for each axis in this experiment?

2. What does a data point on this graph actually represent?

3. What volume would a 20.00 gram sample of this substance occupy?

4. Calculate the density of the substance. (HINT: calculate the slope of the line.)

5. Write the equation for the line and substitute the value determined for the slope.

6. Use the equation to find the mass when the volume is 5.00 cm3.

Sample Data Set 3:

1. Does this graph represent a linear relationship? Why or why not?

2. Identify the dependent variable in this graph. Explain.

3. If the experiment were continued for 30 minutes, what trend in percent transmittance could be expected?

4. Calculate the slope of the line at 5 minutes. What does this represent?

Steps to Drawing an Acceptable Graph

1. Identify the independent and dependent variables
   a. The independent variable is the one "I" control (you manipulate it).
   b. The dependent variable is the one that changes in response to the independent variable.

2. Assign each axis the appropriate variable and label each accordingly. Make certain to include the appropriate units.
   a. The independent variable goes on the *x*-axis and the dependent variable goes on the *y*-axis. An easy way to remember this is with **DRY MIX**. (**D**ependent **R**esponding ***Y***-axis and **M**anipulated **I**ndependent ***X***-axis)
   b. In some physics graphs where time is the dependent variable, time is placed on the *x*-axis. This allows the slope to represent rate.

3. Select and label the numerical scales on both axes. Most of the time, the scales on the two axes will be different.
   a. Determine the "range" (the difference between the largest and the smallest numbers) in the data that is being plotted on the axis.
   b. Next, count the number of spaces ("boxes") on the graph paper along the axis being used. Using the range and the number of spaces, decide on a value for each space along the axis. Typically use only the values **1, 2,** or **5,** or multiples of those values (e.g. 0.1 or 50) for the value of each. This makes plotting a number that is not exactly on one of the box lines easier.
   c. Label the lines of the axis (not all lines need be labeled).
   d. The scale factor that you choose should allow your graph to be as large as possible (it must cover at least *half* of the available graph paper).

4. Plot the data points (choose a shape for the points that will allow them to still be seen once a line of best-fit or best smooth curve has been drawn).

5. Write a title at the top of your graph. The title should clearly state the purpose of the graph and include the independent and dependent variables.

6. If there are multiple sets of data or multiple trend lines, a key must be included. If multiple colors are not available, use different types of shapes for points (stars, circles, squares, etc.) and different types of lines (long dashed, solid, short dashed, etc.).

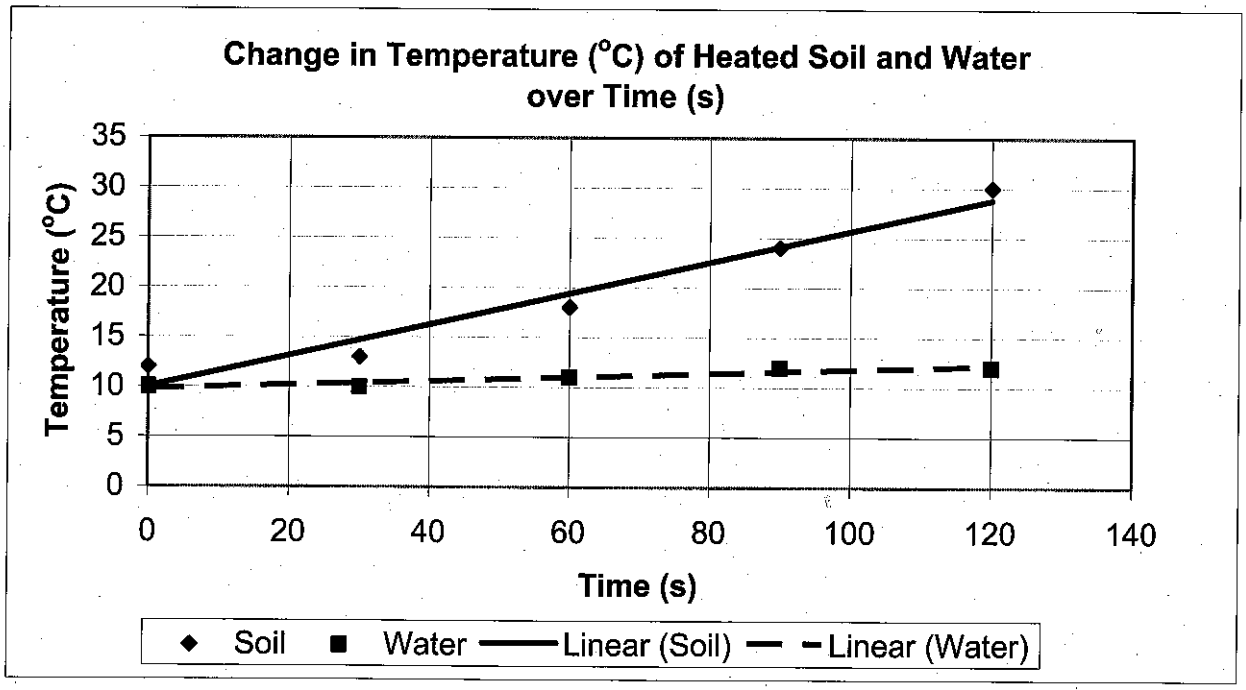
7. Draw a "line of best-fit" that passes through or between as many points as possible.
   a. If the data points appear to lie roughly in a straight line, draw the best *straight line* you can with a ruler and sharp pencil. Have the line pass through as many points as possible, with approximately the same number of points on one side of the line as the other. (Do not *"connect the dots" with straight segments* — it is not likely that the erratic graph that would result actually reflects nature's behavior.)
   b. If the points do not form an obvious straight line, draw the best *smooth curve* that you can. Do not zigzag back and forth to force your curve through every one of the points. (It is not likely that you will have very complex graphs in this class!)
   c. Not all graphs pass through the origin (0,0). If (0,0) is not an obvious point for your data, do not force the line of best-fit to cross the *y*-axis at that point.

Sample of an Acceptable Graph

Time (s)	Temperature of Soil (°C)	Temperature of Water (°C)
0	12	10
30	13	10
60	18	11
90	24	12
120	30	12

Independent Variable = Time (s) (goes on *x*-axis)
(I control the time at which I take the temperature, not the temperature at which I record the time.)

Dependent Variable = Temperature (°C) (goes on *y*-axis)
(The temperature depends on what time you take the reading, it depends on how long it has had to heat up.)



*Notice the lines of best-fit do not pass through the (0,0) mark, just as the data does not.

Slope – rate of change, to calculate slope choose two points from the line of best-fit and use

$$\text{Slope} = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$$

Interpolation – obtaining information from locations between data points
Extrapolation – predicting information from locations beyond your data points